THE TECH

SPECIAL ISSUE--DEPARTMENT OF ELECTRICAL ENGINEERING

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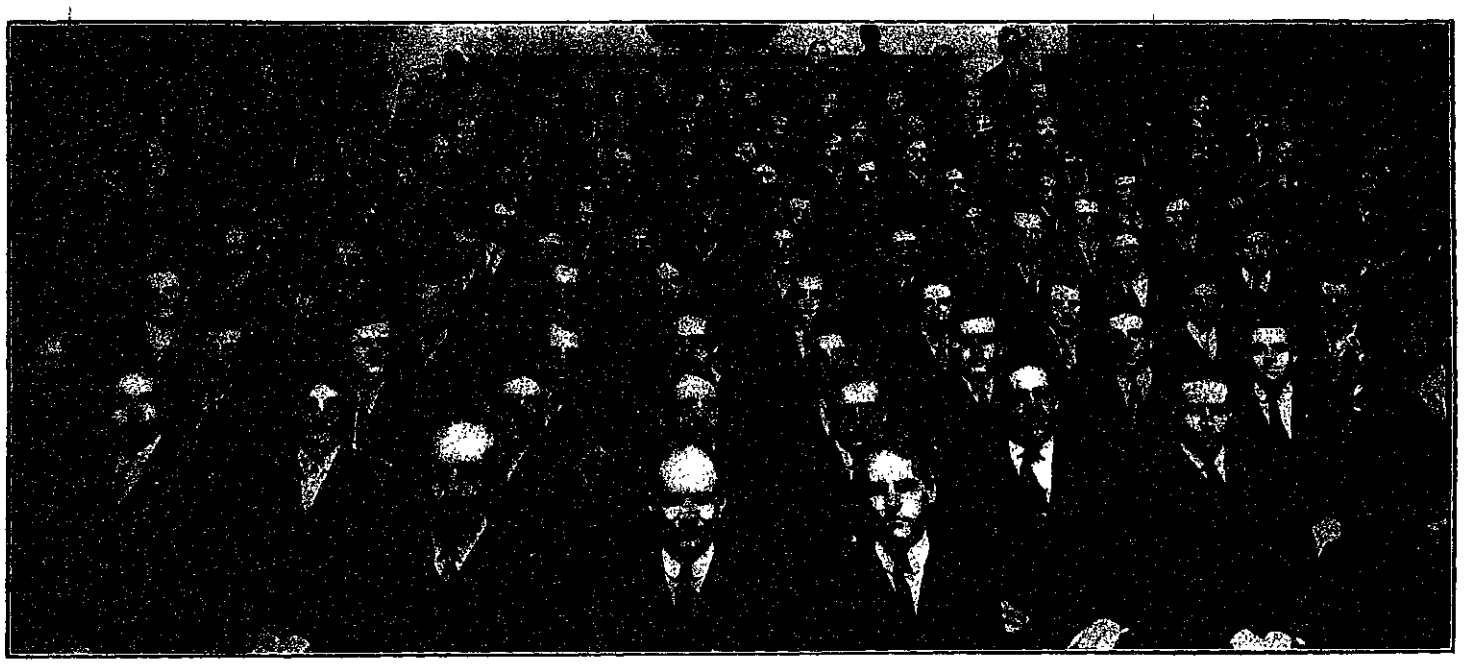

STUDENTS AND INSTRUCTORS OF ELECTRICAL ENGINEERING.

GRADUATE WORK

BY PROF. HAROLD PENDER.

Engineering, in the broadest sense of the term, is the conception, performance and administration of any kind of work, guided in each instance by sound scientific and economic principles. To become a successful engineer in any chosen line of work one must therefore acquire not only a thorough knowledge of the scientific principles bearing on his profession, but in addition must acquire that general knowledge of men and affairs necessary to a sound judgment in all matters related to his profession, and in particular of the economic aspect of the problems upon which he may become engaged. In training young men for the profession of engineering, technical schools very properly lay particular emphasis upon the acquirement of exact scientific knowledge by the student, and upon the application of this knowledge to the solution of such technical problems as one is likely to meet in engineering practice. The time required for such purely technical training together with the equally important instruction in the general or "humanistic" studies, such as literature, history, etc., leaves but little opportunity for original investigations by the student.

Yet there is no more effective aid in the development of a keen and accurate method of thought than the discovering of a logical explanation of some doubtful or hitherto unexplained phenomenon. In addition to the increased power of imagination and analysis thus gained by the investigator, such investigations when carried to a successful conclusion, almost invariably lead to results of considerable value to the profession and to the world at large. It is therefore eminently desirable that a place be found in the curriculum of technical schools for work of such a character, first on account of the training acquired by the student, and secondly on account of the possible addition to the world's store of knowledge. Moreover, the mere fact that work of a constructive nature is being done in the laboratories of a school, even though the number of men engaged in such work are comparatively few in number, creates a spirit of research which, subconsciously, perhaps, stimulates to a greater or less extent every student; and, which is equally important, demands that the instructing staff keep in close touch with the development of

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HISTORY OF THE DEPARTMENT OF ELECTRICAL ENGINEERING

BY PROF. FRANK A. LAWS.

The "Electrician," in its issue of June 10, 1882, begins an account of the Crystal Palace exhibition with these words: "Although we have heard much of the Edison light, few of us had seen it until the present year." This statement is not surprising when it is remembered that the first Edison central station for the supply of electric light by incandescent lamps was established at Brockton, Mass., in 1883. This station was at first patronized by a few venturesome shopkeepers who had to choose between novelty of illumination and the certainty of being able to do business after sunset.

The Boston Edison Company was organized in 1885, the generator capacity at that time being 40 K. W.

The telephone had been invented in 1876, and was coming into general use; in 1883 there were about 16,000 subscribers in the territory covered by the New England Telephone and Telegraph Company. Commercial arc lighting may be said to date from 1878, when the Brush system was introduced. The first commercial electric railway was put in operation in 1881, but no road operating under ordinary traffic conditions was established until 1887.

As for professional societies, the title of the British Society of Telegraph Engineers, indicates sufficiently along what lines electrical work had chiefly developed up to the period of which we are speaking. It was not until 1889 that this name was changed to The Institution of Electrical Engineers. The American Institute of Electrical Engineers was organized in 1884.

The whole domain of alternating current work was as yet unexplored and the commercial transformer had not yet been brought out by Goulard and Gibbs. It was an era of invention and promotion rather than close analysis, and one finds many references in the press to large sums of money paid for worthless inventions. Such transactions did not inspire public confidence either in things electrical or in electricians. Not that some of the best minds were not studying the problems presnted, for instance, such men as Rowland, Hopkinson, Siemens, J. C. Maxwell and Sir William Thomson, and it was the results of the researches of such men that finally placed electrical matters on a sound scientific basis and rendered possible the tremendous developments of the succeeding years.

Naturally enough there was a great and growing interest in electrical matters accompanied by a demand for men who were conversant with the applications of electricity as they then existed. To supply, in a measure, this demand for persons with accurate information, Professor Cross gave an optional course of lectures on "Recent Applications of Electricity." These were given after Institute hours, and were taken by large classes. The great interest shown by the students in these lectures was most encouraging, and very likely helped to direct Professor Cross' attention to the development of more systematic instruction along these lines. Another and probably the determining factor, was that at that time he was engaged in expert work in telephoney and arc lighting work of the very first importance where exact scientific knowledge was an absolute essential. These things had led him to study the possibility of giving at the Institute a course which should fit men for the practice of Electrical Engineering as a profession. The immediate demand as it then existed in the industries would have been satisfied by men of a rather inventive turn of mind whose education had been along the so-called "practical" lines. But a careful study of the problem, and especially of the possibilities involved in the future development of this branch of engineering, convinced Professor Cross that the class of men who would be needed in the future, and who would best contribute to the advancement of the profession must have a wider training. His conclusions were embodied in a circular dated August 31, 1882. This circular contains a statement of the course of study, together with an introductory note, which is here quoted.

"In view of the rapidly increasing development of the various branches of electrical engineering, and the consequent demands for persons conversant with the theory and application of electricity, the Corporation of the Institute of Technology has established a course of instruction bearing more directly upon this subject than any of those

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FUTURE OF COURSE VI

BY PROF. DUGALD C. JACKSON.

Electrical Engineering has come to a scope that is only limited by the breadth of the world's industrial interests. A fully developed electrical engineer is one who can conceive, organize and direct extended industrial enterprises which depend upon applications of the electric current for their commercial success. Men of this kind are becoming leaders in the most important industrial affairs. Defined in this way, electrical engineering is an exacting pursuit, but it is also a comprehensive and influential profession of which the opportunities cannot be exhausted in decades of effective endeavor. This makes it a most absorbing pursuit for any man who possesses the firmness of character and the effectiveness of training required to enable him to reach an influential figure in its practice; but it also makes breadth of training, established on a deeply laid foundation, an absolute essential to real success. If we are to stop for the purpose of analyzing what is meant by real success in its best sense to an engineer, it may be expressed in these words—A power to advance the civilization of the world, a means to improve the conditions and relations of men. These things particularly fall to the lot of engineers who fully honor their calling. With them go the respect and friendship of fellow citizens, influence in affairs of interest and sufficient pecuniary earnings to afford ease of mind to the recipient and happiness to those in dear relationships.

It is appropriate at this point to say that the man who follows the profession of an electrical engineer with fullest success must be a man of science, a man of the world, a man of business, and a man who knows something of the trend of human civilization and human aspirations. No one is likely to satisfy the best ambitions of electrical engineers unless he puts forth his best efforts to make himself master of the fundamental principles of science, and particularly of physical science, and at the same time does his part in cultivating the social relations of man to man. Said in another way, this means that any student in Course VI who wishes to come to the many prizes that electrical engineering offers to its followers, must try to to become reasonably learned in science, persuasive in manner, trained in right thinking, analytical of mind, and exceptional in reliability. The curriculum of the Course is administered with the constant purpose of reaching these ends,

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THE TECH

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BOSTON, MASS., MARCH 12, 1910.

CALENDAR.

Saturday, March 12.

2:19—Train leaves Back Bay Station for Hyde Park.
2:30—Tech Show Principals.
8:00—Columbia University Relay Carnival at New York.

The committee in charge of the issue wishes to extend its most sincere thanks to the members of the instructing staff of the Department of Electrical Engineering who have contributed articles, and to all others who have helped to make this issue possible.

HARVARD TEAM WINS

The Crimson gym team defeated Technology at the Gym last night by the score of 46-8. H. V. Coryell of Harvard was easily the star of the meet, winning three first places. S. Wolfman, also of Harvard, came next with two firsts. H. S. Gott 1910 did good work for the Institute. The horse and parallel bar events were unusually close. On the double bars Gott would undoubtedly have gotten second place, had it not been for a slip at the end of his performance.

The summary of the events follows:

Horizontal Bar—Won by H. V. Coryell, Harvard; F. N. Whitman, Harvard, second; W. D. Allen, Tech, third.

Horse—Won by H. V. Coryell, Harvard; E. N. Cleaves, Harvard, and S. S. Crocker, Tech., tied for second (Cleaves won on the toss.)

Parallel Bars—Won by S. Wolfman, Harvard; F. N. Whitman, Harvard, second; H. S. Gott, Tech, third.

Club Swinging—Won by H. V. Coryell, Harvard; R. V. Moody, Harvard, second; S. M. Baxter, Tech, third.

Flying Rings—Won by S. Wolfman, Harvard; H. R. Rafsky, Harvard, second; R. B. Whitelaw, Harvard, third.

Tumbling—Won by E. N. Cleaves, Harvard; H. S. Gott, Tech, second; N. S. Stern, Harvard, third.

HUSTIS ON RAILROAD WORK

President Hustis of the Boston & Albany railroad gave a talk in the Union on "Railroad Organization." The question of railroads is one of the most important before the country at present, for nearly every current periodical contains an article relating to railroads. When railroads are prosperous the country is prosperous.

A railroad makes more money and keeps less than any other organization of the country. Out of every hundred dollars made, seventy-one are paid out in wages. One of the principal traits of Americans is said to be the desire to get two dollars and go somewhere. The railroad sees to it that it gets its share of the two dollars.

The department which technical graduates usually enter is the engineering and maintenance branch. They start in surveying. Their chief difficulties are that they insist on wanting to build bridges and cannot use the pick and shovel.

College graduates frequently ask where to start in railroading. It makes little difference in what department a man starts; the progress depends on the man, not on the position. He must not find too many things being run wrong in the organizatin. There is a fascination in railroad service. Of the officials, few die and none resign. There is always room at the top for a good man to earn a moderate salary.

COLUMBIA RELAY CARNIVAL

Technology, Brown, Wesleyan and Georgetown are entered in the same relay race at the relay carnival of Columbia University which is held at the Madison Square Garden to-night. The Institute team, consisting of Capt. W. C. Salisbury, P. D. White, L. O. Mills, and H. Lockett, will probably carry off first place. The team is one of the best one-mile relay teams ever at the Institute. Capt. Salisbury is the fastest man in the team and is moreover the best quarter-miler at the Technology. P. D. White is good at any distance from the quarter to two miles. Mills runs a close second to Salisbury. H. Lockett is showing up fine, and is improving every day. The team is well balanced and will, without doubt, show the way to their rivals. P. W. Dalrymple, Tech's star high jumper, will accompany the men, being entered in his specialty. He should place at the carnival tonight.

This meet is the tenth annual indoor relay carnival of Columbia, and it will be the biggest intercollegiate gathering of the year. There will be, in addition to the college relay races, many open relays and events. Harvard is entered in the relay with Yale, Cornell and University of Pennsylvania.

In the college events there will be one and two-mile relays in the championship class and in the secondary class. For the first class, cups have been donated for both the one and two-mile relays, to become the property of the college winning them three times. Most of the Eastern colleges have entered teams in the carnival, and many Western institutions are also entered. There will be a good field in the open two-mile and the sixty-yd. dash should also be crowded with good men, as many college stars will be entered. The high jump is the only field event.

CHESS CLUB PLANS

A meeting of the chess club was held yesterday to discuss plans for the remainder of the year. The new resolutions proposed by the Institute Committee were indorsed after some discussion.

After talking over plans for a spring tournament, it was finally decided to replace this by a series of matches between teams chosen from the members of the club. These will probably be played on Friday afternoon in the Union. It was reported by the secretary that a match was being arranged with Harvard to take place in the near future.

NOTICES

C. E. Society Meeting, Wed., March 16, 4.15 P. M., in 6 Lowell.

Mr. Jos. H. O'Brien of New York City will give illustrated talk on N. Y. Pennsylcania Station..

1910.

Only those who have paid their dues in full by March 15, 1910, will have their names on the Senior Class Day Committee Ballot. Dues may be paid to E. Stuart, L. O. French, R. F. Goodwin, E. M. Potter D. Clapp or W. Union every day from 1.30 to 2.00 P. M. O'Hearn. The treasurer will be in the

1912.

Sophomore Cross-country candidates report at Gym, Tuesdays, Thursdays. Saturdays, at 5 P. M., beginning Saturday, March 5.

LOST—In 20 A or 30 B, Saturday, March 5, at 11.00 A. M., a Slide Rule. Finder will please return to F. C. Taylor '11 at the Cage.

Dress suit in perfect condition for sale. Price $15.00. Will fit a man about five-foot-eight. Inquire R. H. F., The Tech.

GRADUATE WORK

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engineering practice and the related sciences.

At the Institute a certain amount of such training is given the students by requiring from them a thesis on some original problem before graduation. The time available in the senior year, however, is sufficient only for comparatively simple investigations. In many cases one or more years could be profitably spent by a student on work of this character. To provide such an opportunity, the Institute now offers advanced instruction and facilities for research in all departments devoted to the more advanced branches of instruction. To aid those students who show a particular fitness for such work, certain scholarships and fellowships are offered, varying in value from free tuition to free tuition plus five hundred dollars. As an attestation of the successful completion of one year's advanced study and of the presentation of

PROF. HAROLD PENDER.

a satisfactory thesis on some original investigation the degree of Master of Science is awarded. Two or more years' study, accompanied by the presentation of a thesis of high grade is attested by the award of the degree of Doctor of Engineering (or Doctor of Philosophy in the departments of pure science).

In the department of Electrical Engineering there are at present a number of graduate students, two of which are formally candidates for the degree of Doctor of Engineering and three for the degree of Master of Science. These men are taking advanced courses in both the technical and the economic side of electrical engineering, advanced mathematics, electro-chemistry, etc., and in addition meet once a week with the entire instructing staff of the department for the review and discussion of the more important articles appearing in both English and foreign technical journals.

The major portion of the time of each man, however, is devoted to experimental research. The investigations now in progress are the following:

Experimental study of the changes produced in the properties of solid dielectrics when subjected to high electric stresses, with special reference to the effect of such changes on the disruptive voltage of insulated cables. Also a study of the feasability of grading the insulation of cables, from both the theoretical and economic point of view.

Study of the transient potential gradient in a coil having an iron core when a given voltage is impressed across its terminals, with special reference to the choking effect of the end turns of a transformer winding when switched into circuit.

Investigation of the effect of heat treatment on the magnetic and electric properties of silicon iron, together with a metallographic study of the changes of structure produced by such treatment. This investigation has been undertaken with the hope of arriving at some definite quantitative relations between the various effects produced.

Experimental determination of the breaking strength, deflection, and point of rupture of wooden transmission poles when subjected to lateral stresses, with special reference to the effect of the nature of the soil in which the poles are set.

Experimental check of the formula for self induction and electrostatic capacity of parallel conductors, both solid and stranded, for both single and three-phase currents. Also a check of certain approximate formulæ for the capacity of multi-conductor cables enclosed in lead sheaths.

LETTER FROM GRADUATE

BY MR. CLARENCE RENSHAW.

To the Editor of The Tech:—

Just when or why I became interested in electrical matters, I can not recall definitely. I think it was due to some articles, on how to make batteries and perform simple experiments, which appeared in the Youths' Companion just about the time I was studying Physics, in the first-year class of the high school. I do not believe that I ever made a definite decision to adopt Electrical Engineering as a profession; it seemed to follow as a matter of course.

During my term at the high school, I became imbued in some way with the idea that all college-trained electrical engineers were helpless theorists, and so, on graduating, I decided that I would not go to college, but would find employment in some electrical factory and "work my way up." I made rapid strides in the fan motor factory where I first found work, and advanced from a salary of $3.50 per week to $7.50, in less than a year. Soon after I achieved this distinction, however, the concern became bankrupt. Another position, this time with a thermostadt company, ended in a more or less similar manner; and then, finding it difficult to obtain any electrical work, I decided that I would go to college, after all.

The decision as to which college I would attend, was entirely in my own hands. It was made in favor of the Institute largely on account of the clear and businesslike arrangement of the Institute catalogue. The statements that were made there regarding the necessity for a broad training, rather than a purely technical one, appealed to me, and I could readily understand exactly what the entrance requirements were, while the catalogues from other prominent technical colleges seemed hopelessly confusing. Once enrolled at the Institute, I was quickly convinced that I had chosen wisely. I have never forgotten this incident, however, and that it was the excellence of the catalogue which really settled my decision, and many, many times since, I have taken greater pains in the preparation of reports, specifications, letters, etc., on account of this recollection.

In choosing the Institute in preference to other schools I did so because I believed that it offered the best course in Electrical Engineering that could be had anywhere, and my opinion now is the same that it was then. In looking back over the curriculum as I knew it, however, I recall many details that I wish could have been different. One of our professors, in closing his course just before graduation, told us that the Institute had provided us with a complete set of tools for our life work, but that we, ourselves must learn the uses of them. I regret that this was but too apt a simile, and feel that we would have been much better off, if more time had been given to acquainting us with some of the practical possibilities of the subjects taught. During my course, I was fortunate in having a friend who was employed by the Boston Elevated Railway Co. in looking after their underground feeder cables. It was his duty, every week, to measure the insulation resistance of each cable, and I visited him on one occasion while this was being done, and had the whole process explained to me. Soon after this our class took up the study of Differential Equations, and talking to my friend one day about the apparent uselessness of this subject, he told me that the formula which he used in making his cable tests was derived by the aid of Differential Equations. My respect for the subject was at once greatly increased, and I am sure that if the entire class could have been given the benefit of this and similar incidents, their recitations in Differential Equations would have shown marked improvement and the subject would have made a much more lasting impression on them.

Nor was it merely the purely academic studies that could have been

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FUTURE OF COURSE VI

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but it is necessary for the student to put his mind to the test of his own education and not rely solely on professors or curriculum if he expects to go beyond the timber line of ordinary achievement. With this clearly in mind, I am will ing to say that I do not believe that there is any place in the country where the study of electrical engineering can be caried on so favorably as at Technology. This applies equally to undergraduate study and to students following graduate study and research. The latter should steadily become more important for the highest training of the ablest young men entering the profession of electrical engineering, and the opportunities of pursuing them should be embraced by a steadily increasing number of students who desire to cultivate the keenest power of analysis and reasoning which are pre-eminently useful to the electrical engineer.

Of itself, much inspiration may arise from studying electrical engineering in a pioneer institution in the field, which

PROFESSOR DUGALD C. JACKSON.

has contributed a large body of young men already becoming and become eminent in engineering and industrial life. The electrical engineering course at Technology in this respect holds a remarkable place. Its early establishment and its fine body of graduates make its influence felt through all the ramifications of electrical industries.

The curriculum of the Course is planned to lay broad and deep in its students the foundations for sucessfully following the duties of electrical engineers. Students who come to the Course from high schools and preparatory schools are expected to obtain at the Institute certain definite training; including the additional training in the use of the English language which is requisite to clear thinking, clear writing and persuasive speech, and also some foreign language for the purpose of adding strength to the language acquirements; the collateral art of expression by drawing, which goes hand in hand with language as an art belonging to successful engineers; mathematical training, to establish accurate reasoning powers and also give a useful and powerful tool in the solution of many problems of electrical engineering; the science of chemistry and the science of physics, to give an acquaintance with the known facts of nature with which the engineer must work, and the relations of those facts with each other; applied mechanics, which is the philosophy of matter, force and energy and is the backbone of an electrical engineers' power; and much in regard to the many useful applications of nature's forces. Students coming from the college courses pursue such parts of the foregoing subjects as have not been suitably covered in their previous courses.

No man who becomes an electrical engineer can confine his study to electricity and magnetism, but, having mastered the fundamental principles, he must also learn in regard to the characteristics and uses of constructive materials, their correct application to the building of actual structures; the meaning of kinematics to the engineer, and the processes of designing, constructing and using real machinery; something of the special principles of thermodynamics and hydraulics and the ways in which those principles are utilized in the designing, constructing and operating of prime movers; and also something must be learned of the efficiencies of numerous industrial processes, for applied electricity has invaded nearly all fields of industry. Besides these numerous branches, our electrical engineering students are expected to learn to reason clearly and rationally in regard to the specific principles relating to applied electricity and magnetism, including all their diverse factors, and the ways in which these principles enter into everyday practice.

This is a formidable array of important study, but it may be successfully accomplished by an alert minded student in the allotted four undergraduate years and still leave the time requisite to pursue those general or humanistic studies needed to stir ambitions and give a familiarity with the development and manners of mankind. But it is preferable for the ablest men to add to the undergraduate years one or two years of graduate study which are very effective in enlarging and cultivating the scope of the student's vision. Any young man who successfully follows this Course ought to develop those fine but rare qualities of mind called initiative, originality, self-reliance, observation, tact, and reliability. Having these added to knowledge and power in the use of knowledge, he should find electrical engineering a pursuit of pervading fascination.

There are many great places in the industrial world within reach of well-trained and able engineers, and a full proportion belong to electrical engineering. Indeed, the well-trained, able man can usually determine his own place as an electrical engineer, provided he has industry. perseverance, and mental courage to first prove his worth by work. Electrical engineering is an exacting profession in which there is not a great demand for mediocrity, but any really able, ambitious, well-trained young man whose tastes lead him to try electrical engineering will find his services in gratifying demand after he has made sufficient start to prove his industry and ability.

SUBSIDIARY OPPORTUNITIES FOR STUDENTS

BY MR. RALPH G. HUDSON.

The object of this article is to acquaint prospective students in the course of Electrical Engineering with certain opportunities possessed by such a course at the Institute, which are not included in the prescribed curriculum of the department.

Students entering the third year should join the Electrical Engineering Society. The dues are nominal ones, and there are at least three distinct advantages to be obtained by such membership. At the monthly meetings of that Society, the members not only have the opportunity to hear and meet successful engineers who make addresses at these meetings, but the assemblage itself is the only one in which each student may meet all of his classmates to discuss informally the various problems of mutual interest. It is a Society designed to promote a social discussion of business problems. The Society furthermore holds several interesting excursions each year. These trips have included visits to the works of the General Electric Company at Lynn, and the Fore River Ship Building Company at Quincy, as well as to the various power-stations of the Boston Elevated Railway Company and the Edison Company. The insight gained in these trips of the practical adaptation of the theory studied at the Institute is extremely valuable.

Third-year students should also become Student Members of the American Institute of Electrical Engineers. Such membership at $3.00 per year for three years entitles the student to the Proceedings of the Institute and also gives him the privilege of attending the meetings of the Boston Section. The papers given at the monthly meetings of the local section and the discussion following these will prove of great value in developing the student mind to the realization of the breadth of the electrical engineer's efforts and will keep the student informed as to the trend of engineering developments.

All students should make it a point to attend the lectures of the Society of Arts as far as is possible, and especially those of electrical character.

Not too much can be said of the opportunities offered by the extensive libraries of the Institute. The student should make it a regular habit to look over the contents of the Electrical Engineering Library as well as those of the Physical and Mechanical Engineering Libraries. A general knowledge of the books available in these libraries will prove of great value at various times when the student is in need of explanation upon any suoject. In addition to this, the student should glance over the various magazines on file in these libraries. Very often, the student's conception of certain subjects will be strengthened or made clear by articles appearing from time to time in these magazines.

It must also be borne in mind by all students that the course, although very complete in its laboratory instruction, offers more theoretical instruction than practical, and it is therefore advisable that all students spend a part at least of their summer vacations in practical work.

The attention of the students is called to the fact that in the senior year, an inspection trip is made to the General Electric Company's works at Schenectady, and to the various plants at Niagara Falls. This trip sometimes includes a side-trip to the sub-stations at Buffalo, and on the return to the large power-plants in New York City.

As previously stated, this article is written to prepare prospective students in the side issues and the effort is made to awaken all participating in a course in Electrical Engineering to the various subsidiary opportunities possessed by such a course at the Institute.

RELATION TO OTHER ENGINEERING COURSES

BY PROF. HARRISON W. SMITH.

The extensive application of electricity in many branches of industry is a matter of common observation and articles are constantly published in the technical magazines dealing with special features of the subject. A conspicuous example is to be seen in the design of a modern machine shop where individual motors are employed to drive the larger machine tools while the smaller tools are arranged in groups and driven by a single motor. In this manner the capacity of the tools for rapid working is increased and at the same time power is saved by the elimination of long lines of moving shafts and belts.

Another example of the application of electric power is in mining operations where electric locomotives are used to haul cars, and motors are employed to drive ventilating fans in positions too remote to admit of the use of any other motive power. Again, some mines may be worked by electricity obtained from distant water power under conditions where the cost of fuel and the grade of ore would otherwise prohibit profitable operation.

One of the most striking developments is in electro-chemistry where cheap power has aided the growth of new and valuable industries.

It is unnecessary to cite numerous examples to indicate that a knowledge of electrical phenomena is essential to the engineer in many different branches of engineering, but it is important to consider the kind of knowledge that will be most useful to him. Thus when the non-electrical engineer is called upon to consider a problem dealing with an electrical installation, the factors upon which he must base his solution are, in the first place, the performance, that is the degree of satisfaction with which the electrical apparatus will meet his requirements, and, in the second place, the cost. With regard to the latter the same general principles hold that apply to any engineering proposition and the detailed information necessary in any problem must be obtained to suit the particular conditions. Naturally a proper treatment of the question of cost will involve a knowledge of the performance of the machine which thus becomes of special importance to the non-electrical engineer, and is the chief object to be kept in mind in arranging a course for the non-electrical engineering student.

Such a course must contain a certain amount of specific information relating to the operation of different types of motors, the methods of controlling speed, the operation of generators and the like. More specialized information would in

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ELECTRICAL LABORATORIES

BY PROF. RALPH R. LAWRENCE.

It is impossible to make engineers in a technical school or college. All that can be hoped to be accomplished is to ground students in the fundamental principles underlying their chosen branch of engineering, to teach them to think clearly and logically and to have the proper initiative in handling new problems. The laboratory is particularly valuable in giving men this training, but in order to produce the best results, it must be conducted in such a way as to leave the students as free as possible in planning their work. Each experiment should call for a definite result, but the method by which this result is to be obtained should be left for the student to plan.

Laboratory experiments which are laid out to resemble more or less closely commercial tests, too often teach little more than dexterity in reading instruments, especially when they are conducted with more or less detailed notes or directions. Commercial tests can seldom be duplicated in the laboratory, as they not only require larger units than can economically be used, but also necessitate more time than is usually available. Moreover, the actual electrical connections can seldom be made by the students, and large apparatus would necessitate the presence of an assistant under whose direction the experiment would actually be performed.

Laboratory work to be most effective must supplement the lecture and class room, and should be made to bring out the theoretical points there discussed. The closest possible relation should exist between the lecture room and laboratory.

This close relation has always existed in the Electrical Engineering Department, especially during the senior year. Each laboratory experiment is planned to bring out the characteristics of the particular type of apparatus to be used. All connections are left for the students to make, and the entire conduct of the experiment rests with them, the work being conducted according to directions they have themselves planned and written before coming into the laboratory.

The actual experiment is performed by the students working in pairs.

The present method of conducting the work in the Electrical Engineering Laboratory, for Courses VI, XIIIa, and XIV is the development of the system suggested by Professor Clifford, about eight years ago. Under this system each student, before coming into the laboratory, is obliged to submit a preliminary report which must be approved before any laboratory work is done. No notes are given the men, all they receive is a brief statement of the results required in each experiment and the size and rating of the apparatus upon which it is to be performed.

Before each laboratory exercise, the men meet in one of the smaller recitation rooms to write up their preliminary reports, and receive their assignment for the following laboratory exercise from the assistant who is present to give such suggestions as may be needed by the students in writing up their reports. Lecture notes or text-books, except those dealing with laboratory instruction, are permitted. During the first fifteen minutes the students may go into the laboratory to inspect the apparatus to which they have been assigned.

The preliminary reports take the place of the printed notes used in connection with most laboratories. In these preliminary reports the men must outline the experiment, give diagrams of connections, and state what measurements must be made. The number and sizes of all instruments required must also be estimated. These preliminary reports are read critically and returned for correction several days before the laboratory exercise. Having made the corrections, the students take their reports to an instructor for final approval.

When the students enter the laboratory, one of each pair who are to work together, takes his approved instrument list to the instrument room and receives the required instruments. The apparatus is then connected up and the experiment performed with little or no help.

The data obtained is worked up independently by each man, and submitted in a final report. This final report, in addition to the results, must contain a brief discussion of points which have been brought out by the experiment.

OUTLOOK FOR GRADUATES

BY PROF. WM. E. WICKENDON.

Electrical engineering is peculiarly a profession of young men. There are few fields of human endeavor in which so many of the greatest names are borne by men who have not yet passed the climax of their powers. The reason for this state is found in the extreme youth of the profession, as its history extends back but little more than thirty years. It is a natural inference that a profession so vigorous and virile affords the graduate exceptional opportunities, some of which have no precise counterpart in the older fields of engineering. Electrical engineering is not overcrowded, in America at least, and it is a field less easy of access than many others. The intelligent artisan can master much of its empirical data but finds its precise scientific foundation a difficult barrier to professional standing. Such a barrier is not insuperable, but it is none the less true that few men enter the profession from the ranks of skilled labor. In no other branch of engineering is the highest grade of professional education at so great a premium, though the prospective electrical engineer at graduation has acquired relatively less of the practical data of his profession than the men of other courses. Furthemore, the graduate finds much of the more highly specialized theory of the profession still before him, stimulating the continuance of the habit of study as a means of progress.

It is frequently the case that graduates in electrical engineering at the outset are called upon to perform more menial tasks and receive smaller salaries than their classmates of other courses. In soem cases it amounts to a disillusionment to discover that one has little information immediately convertible into cash. On the other side of the case, however, are the possibilities of more prompt individual recognition in a rapidly developing field whose processes and standards have not yet settled into a traditional mold. The professional outlook for young men is therefore promising.

Successful engineers have reached the general concensus of opinion that two years of apprenticeship training afford the average graduate the best initiation to the profession. Much of the service required is doubtless below the graduate's highest abilities, the hours of labor are long, night work is often required and the associations of the shop differ from those of the chapter house and social club to an extent not always agreeable. The work, however, is usually carefully planned and the apprentice passes from department to department in rotation with a long enough time in each to afford an intimacy with the essentials. In the process the young engineer learns to fit himself efficiently into a great organization. He develops the indispensable capacity for co-operation with other men of all ranks and stations. In many of his problems the most important tools of the engineer are men, and a knowledge of their characteristics will still be indispensable when the calculus is rusty and precision of measurement forgotten with the formal rules of grammar. Many students anticipate a good portion of their apprenticeship by work during vacations, the gain in some cases being as great as a year.

Given the proposition that apprenticeship is necessary in the average case and, to some extent, desirable in every case, there remains the problem of determining where it may best be undertaken. As a rule the graduate who is in doubt as to the particular phase of electrical engineering which he wishes to pursue will do not amiss to enter the employ of one of the large manufacturing companies if the opportunity is open. He will thus gain intimate knowledge of many aspects of engineering which will guide him to his individual opportunity. To the man whose future work is to be the designing, construction, selling of, erection of electrical machinery this type of shop apprenticeship is wellnigh indispensable.

Many engineers have found the shop course an excellent foundation for the requirements of central station and electric railway practice. In recent years some of the larger operating companies have provided special training courses which give a more direct introduction to their special problems, methods and forms of organization.

Illuminating engineering is at present a peculiarly attractive field because of its recent recognition and the present rate of its development. An association of the leading lamp manufacturing companies offers to graduates an excellent course of training which fits them for responsible positions in the research, commercial and technical departments of the several member compaines and with the central stations with whom they have close relations. The illuminating engineer is a valuable adjunct to the contract department of a large central station company. Graduates frequently enter this field as solicitors for new lighting business with good success.

It has been said that the telephone engineer is more kinds of an engineer than any other sort of man. Telephony is the most rapidly growing semi-public industry of the day and this growth involves many broad and exacting technical problems. In its artisanship telephony is largely a matter of refined detail, but its engineering proglems demand exceptional breadth of view and afford most attractive opportunities to well-qualified men. The important man-offer well-planned courses of training in the essentials of telehpone engineering and can generally accommodate as many graduates as desire to enter upon such work.

The work of teaching is always attractive to a small percentage of engineering graduates. Some enter upon it as a permanent profession, renouncing the expectation of large financial gain for the sake of primary rewards not to be measured by commercial standards. Other seek teaching position for a brief period to gain the admirable review of fundamentals and the cleared perspective of the various aspects of engineering thus afforded. In either case a position which provides the opportunity to pursue graduate study and research should be sought by the beginner in preference to one whose chief attraction is a large salary. One or two years of graduate study, with or without teaching duties, will generally prove an excellent investment to men of initiative and ability.

Whatever avenue of approach to the profession the graduate may select, the present year should be a peculiarly favorable one in which to begin a career. The present rate of increase in the volume of business and the development of electrical enterprises is epoch-making. Although the demand for the Institute's product has ever exceeded the supply, the present year bids fair to establish a new record. No graduate need fail of success with the plea that he was not wanted.

In conclusion, it may be of interest to note that 720 men have been graduated from Course VI in the twenty-five years of its history. The standard of attainment set by these men has been admirable. Many have attained great eminence, enriching the profession by their researches and experience and reflecting no small honor upon the Institute and upon their course.

COURSE RELATIONS

(Continued from page 52.)

many cases be useful, but it must be clearly understood that a knowledge of facts alone is not sufficient to give an engineer that breadth of view by means of which he may intelligently consider all features of a problem. Thus, detailed information should be regarded of value, not so much for itself, as in illustration of the fundamental principles; for a sound knowledge of fundamental principles can alone furnish a basis for the intelligent interpretation of the performance of electrical machinery.

A very great advantage of sound training in the fundamentals of electricity for students of other sciences is to be found, as Dr. Steinmetz has pointed out, in showing "the close relations that exist between all branches of science no matter how different they appear at first sight."

HISTORY OF DEPT.

(Continued from page 49.)

which have hitherto been offered to the student. This has been done by establishing an alternative course in Physics, to be known as Course VIII, B, which will differ from the present Course VIII chiefly in the continued study of electricity instead of the pursuit of other branches of Physics, and in the introduction of a considerable amount of practice in the Laboratory of Mechanical Engineering and the Workshops, in place of Chemical Analysis. An endeavor will be made to give to students pursuing this course a knowledge of the theory of Electricity sufficiently extensive to prepare them for all ordinary electrical work and which shall also serve as a foundation for more advanced study. They will receive instruction in the Physical Laboratory in the various methods of electrical testing. Special in-

PROF. F. A. LAWS.

struction regarding Land and Submarine Telegraphy, the Telephone, Electric Lighting, and the electrical Transmission of Power will be given, and the study of Acoustics will also be required in view of the art of Telephony.

"The nature of the course is evidently such that facility in the acquisition of both mathematics and physics is essential to pursuing it successfully."

We have in this, a concise statement of the chief characteristics of our Course in Electrical Engineering, as it exists today, and of all other successful courses in the subject as they have been established elsewhere. This circular announced the establishment of the first course in Electrical Engineering in the country, and marked a distinct step forward in the matter of technical education.

Work in the new course was begun in the fall of 1882, there being six regular students. Only students who were to take the full course, beginning with the second year, were accepted. The specialized work of this first class was of three years' duration as it is at present, and the first class was thus graduated in 1885.

In 1882 the whole Institute, with the exception of the shops, was accommodated in the Rogers Building. The dynamo used by the Electrical Engineering division was a two-light Brush machine; it was set up in Professor Richards' domain so that it could be belted to his steam engine. The other electrical apparatus was in the space now occupied by the library. In 1883 the Walker building was completed, and in the spring of 1884 the Physical Department was transferred to new quarters. The power necessary for the operation of the various machines was transmitted by a line shaft which ran through a tunnel between the Rogers and Walker buildings, and was furnished by a Porter Allen engine in the Laboratory of Mechanical Engineering then located in the basement of Rogers. In 1887 Mr. Edison presented to the Institute one of his commercial dynamo machines. Both it and the Brush machine are still in use.

All the working of electrical measurement and testing was concentrated in Room 10, which was then considerably smaller than at present, part of the space being occupied by apparatus cases and a small recitation room.

Concerning the subject matter of the instruction in those early years I shall speak in the light of my personal experience at the Institute, which began in 1885. Work of the first year was in general of the same preparatory character as at present, though the mathematical requirements were less advanced than at present. In the second year the strong course was in Physics, and in view of recent changes in Course VI, it is interesting to observe that instruction in the important subject of mechanics was given not only in the lecture room, but in supplementary class room exercises, when there was time for the solution of problems under the eye of the instructor.

The detailed study of electricity began as at present in the third year. Professor Cross conducted the class which numbered about fifteen men. The text-book used was Fleeming Jenkin's Electricity and Magnetism, a book remarkable in its time for the manner in which it dealt with the subject, and its insistence on exact measurement. It was written by one with a rare faculty for correlating theory and practice, for Jenkin was an engineer of distinction and a student of science as well. His point of view is well illustrated by the following extracts from his preface: "In England at the present time it may be said that there are two sciences of Electricity—one that is taught in ordinary text-books—the other, a sort of floating science known more or less perfectly to practical electricians, and expressed in a fragmentary manner in papers by Faraday, Thomson, Maxwell, Joule, Siemens, Matthiesen, Clark, Varley, Culley and others. The science of the schools is so dissimilar from that of the practical electrician that it has been quite impossible to give students any sufficient text-book. A student might have mastered Delarive's large and valuable treatise and yet feel as if in an unknown country and listening to an unknown tongue in a company of practical men. It is not a little curious that the science known to the practical men was, so to speak, far more scientific than the science of the text-books."

It was such a book that Professor Cross took for his text, filling in the gaps, when necessary, and bringing the subject matter fully up to date, and I doubt if ever a class was subjected to closer questioning on what they were supposed to know. This course was followed by one on Direct Current Generators and Motors. Professor Cross also conducted this, using as a text-book Silvanus P. Thompson's Dynamo Electric Machines. The purely theoretical work, given by Mr. Clifford, was along the lines of Electrostatics and Potential, for the many ramifications of alternating current theory simply did not exist. The laboratory instruction was almost wholly in the lighter electrical measurements and was in charge of Professor Holman. This arrangement continued until Professor Holman's retirement on account of ill health in 1896, at which time the work in Electrical Measurements was undertaken by the writer. Gradually the dynamo laboratory was developed, Professor Puffer devoting himself to it and the photometric work.

To Professor Holman the Institute owes a lasting debt of gratitude for his efforts which resulted in the establishment of our high standards of requirement in the experimental work of electrical measurements and dynamo testing. That there might not be a great waste of time through misdirected effort in this and other experimental work, he devised a course in Precision of Measurements and introduced it into the curriculum. Professor Holman gave himself without stint to the improvement of the methods and the equipment of the laboratories. Much of what he did was accomplished under circumstances which would have daunted a less courageous man. For years his health was not robust, and he was a great sufferer, but he never allowed this to warp his judgment or render crabbed a nature which was not without fire.

In 1898 a large room in the basement of Walker Building was set apart as a dynamo laboratory. It was equipped with a 75 h.p. Westinghouse engine, belted to a jack shaft from which the various machines were driven. In 1893 these were as follows: a 150 light Edison dynamo; a 200 light Thomson-Houston machine; a 60 light Weston machine; a 500 light Thomson-Houston alternating machine; a 300 ampere U. S. machine of low voltage, and a 3 light Brush dynamo.

Very early it became apparent that in every class there were a few men of superior capacity who would profit by more advanced instruction than that given in the regular order of things, and accordingly optional advanced courses were given which were open to those qualified. It was in this manner that the course in alternating currents was begun in 1891.

For a number of years the Institute catalogue contained a general statement concerning graduate courses leading to the Master's degree, and in 1901 the Department of Electrical Engineering definitely offered such a course and in the catalogue of that year may be found the scheme of studies. In 1903 it became possible to obtain, after a minimum of two years' graduate work, done in residence, the degree of Doctor of Engineering.

A distinct course in the theory of alternating currents was given for the first time in 1891 by Professor Clifford to a few men who formed a special class; from that time to the present, this subject has been of increasing importance in our curriculum.

The next considerable advance in equipment was in 1896 when an experimental plant was installed solely for use in regular laboratory instruction in connection with the course in dynamo testing and dynamo electric measurements. It consisted of two similar 25 k. w. machines, belt driven from a Westinghouse compound engine, the latter being fitted with a condenser and all necessary auxiliary apparatus. This set is now installed in the Lowell Building.

Changes in the course of study were made as the science and art of the electrical engineer advanced, and the course at the Institute always kept its position as a leader in this class of education.

In 1902 it was decided to remove from the Department of Physics that portion of the work which was of a distinctly technical character, and the separate Department of Electrical Engineering was created. Dr. Louis Duncan, sometime Professor of Electrical Engineering at Johns Hopkins University, and later a practising engineer in New York, was placed in charge. At that time the Loweli Building was constructed and sufficient space allotted to the various parts of the work so that they might properly develop with the rapid progress of Engineering. In 1904, Professor H. E. Clifford was made acting head of the department. His administration was characterized by a close study of the needs of the profession and an adaptation of the instruction to meeting these needs adequately. It was also characterized by a careful study of the requirements of individual students and the establishment of post graduate work of a most advanced character. The watchword of Professor Clifford's administration was "Develop the power of analysis," and to the young graduate himself was left the acquirement of the various short cuts and tricks of trade which all engineers must have at their command.

Professor Clifford never lost sight of the fact that to get the best results, "team work" on the part of the instructing staff was absolutely necessary, and he spared no pains in bringing this about, one of the most effective agencies being the departmental conferences where all questions of interest were frankly discussed.

In 1906 Professor D. C. Jackson, Professor of Electrical Engineering, at the University of Wisconsin, was made head of the department. Professor Jackson, after graduate work in electrical engineering at Cornell University, entered the employ of the Sprague Electric Railroad and Motor Company, thus gaining his electrical engineering experience during the early and trying years of electrical development. In 1891 he was called to the University of Wisconsin and served there continuously until his coming to the Institute, at the same time being engaged, together with his brother, Wm. B. Jackson, in conducting an engineering office. The questions of finance connected with electrical undertakings of large magnitude possessed a great attraction for him, and gradually his interest shifted from the purely constructional engineering side of the work to questions of engineering economies. So that he now has to do with such large questions as, for instance, the proper determination of telephone rates in the State of Massachusetts, this problem necessitating an immense amount of work. He has also investigated questions connected with the telephone franchise in the city of Chicago, and done many other pieces of work of like magnitude. The reaction of these activities on his instruction work is seen in his course on Public Service Corporations, given to the post-graduate students. In addition, Professor Jackson has done much work of an expert nature in connection with patent cases. The principal changes introduced into the course of study since Professor Jackson took charge of the Department are the beginning of Applied Mechanics in the second instead of the third year, and the extension of the work in Hydraulics.

With Professor Jackson came Professor G. C. Shaad, also of the University of Wisconsin, who took charge of the work in electrical installations and the allied excursions. In the spring of 1909 Professor Shaad was called to the chair of Electrical Engineering in the University of Kansas. There he became head of the Department. At the same time Professor Clifford tendered his resignation, after twenty-three years of service to the Institute, to become Professor of Electrical Engineering at Harvard University. These changes rendered it necessary to bring to the department two new men. To fill these positions Dr. Harold Pender came from New York City, where he had been engaged in electrical engineering work of a general character, and Professor W. E. Wickenden from the University of Wisconsin, where he had been teaching subjects allied to those given by Professor Shaad, whose place he took.

LETTER FROM GRADUATE

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made so much more real by the injection of a little human interest. Many of the professional subjects, such as Thermodynamics and Applied Mechanics, suffered severely from the abstract manner in which they were presented. Whether it was because I was better prepared to digest the electrical subjects and to add my own "human interest," or not, I do not know, but for some reason it seems to me that the mechanical engineering subjects were much more lacking in this respect than the electrical ones.

One of the greatest disappointments of my entire four years was the course in the Mechanical Engineering Laboratories. As a Freshman and a Sophomore I often wandered around among the engines, pumps, etc., and looked forward longingly to the day when I would be privileged to handle them and know all about them. But, alas! that time never came, for as a Junior and a Senior, I found myself somewhat in the same position as the little girl in the nursery rhyme:—

"Mother, may I go out to swim?"
"Yes, my darling daughter;
Hang your clothes on a hickory limb,
And don't go near the water."

For the machines were always thoughtfully started and adjusted by the instructors before the students arrived and all the latter had to do was to take a few indicator cards, or read a speed counter for a while, and then make a lot of calculations. One shining exception, however, was the little Harris-Corliss engine on which we were allowed to set the valves and to actually open the throttle ourselves and make the wheels go around. I believe that the two hours which I spent on this test were of more real benefit to me than any ten other assignments in the course.

This matter of actually handling the machinery, themselves, in a laboratory of this sort, is of vital importance to the students. It may seem a small thing to open the throttle and start a

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E. E. SOCIETY

The Electrical Engineering Society ranks as one of the foremost professional societies at the Institute. The object of the Society is twofold, first, to bring together socially the men in Course VI, and, second, to give the members some idea of the practical application of the studies they are pursuing. To accomplish these objects, monthly meetings are held, at which the Society is addressed by men prominent in electrical engineering, excursions are made to plants of interest around Boston, and an annual dinner is given during the latter part of the year.

LETTER FROM GRADUATE

(Continued from page 54.)

ten-horse-power engine, or to close the switch and bring a five horse-power motor up to speed, but a boy who has never done it feels more confidence in his ability as an electrical engineer after one such experience than he does after a week of reading instruments and plotting curves. This fact seemed to me to be appreciated by the electrical authorities and in all of the laboratories under their charge the students had practically the entire handling of the apparatus with which they were working. I believe that this feature makes Course VI one of the strongest courses which the Institute offers.

A serious fault, which seems to be common to the engineering courses of practically all technical colleges, is that not nearly enough attention is given to teaching those fundamental methods of carrying on business, which the students should know if seeking employment in any of the commercial departments of technical industries or even to enable them to manage properly their own personal affairs. Probably three-fourths of the college graduates who enter the Engineering Apprenticeship Course of the electrical manufacturing company with which I am connected, find, at the end of their course, positions in the commercial rather than the engineering branches of electrical work. All of these men are seriously handicapped by the lack of even the most elementary knowledge of ordinary business forms. Perhaps half of them may have heard of a "Sight Draft" or a "Bill of Lading"; fewer still would have any idea how to find the credit rating of a customer; and to find one in fifty who could write a creditable business letter more than half a page in length, would be unusual. On this account, many of these men, after four years at college, and two years in the shop, must still take lessons in certain branches from the office boy.

Even to those who take up strictly engineering work, a training in such matters as the above would be exceedingly valuable. It is generally conceded that a scientifically trained business man has a far-reaching advantage over his non-technical competitors, and my own observations would indicate that the commercially trained engineer has an equal advantage over his less sophisticated brethren.

The curriculum of Course VI, as I knew it, included a brief course on the "Economics of Corporations." This I found most valuable, and although I believe it should be greatly extended to include business forms, elements of commercial law, accounting, etc., I would have given up any other subject in the entire four years' course, to which an equal number of hours was devoted, rather than have missed "Economics of Corporations."

No matter how excellent a college training a young man may have had, or how much he may have profited by it, should he enter the apprenticeship course of one of the large manufacturing companies, his first few days at work are likely to prove one of the most discouraging experiences of his life. Coming from a college, where several years of attendance have made him familiar with every detail of the surroundings, he finds himself almost lost in the vastness of a large factory. It was difficult enough for him to begin recitations at nine o'clock, but now he must report for work at seven. The subjects which he has been pursuing for the past four years seem absolutely useless in his new surroundings, and entirely different standards seem to prevail. And, somewhat like the Irishman, who visited France and was greatly surprised to find even the little children on the streets speaking French fluently, while he, a grown man, was entirely ignorant of it, so our erstwhile lordly Senior finds that apparently he alone, of the thousands of working men, women and children around him, seems not to know what tasks are expected of him or how to perform them. This feeling soon wears off, however, and he begins to be interested in his work and to realize the possibilities for learning which are within his grasp.

With reference to the value of such courses, and the advisability of entering one of them at a salary of about $40.00 per month, rather than taking a regular position, if one can be obtained, at $50.00 or $60.00, I would certainly advise the former for all young graduates who can possibly arrange for it. I did not feel this way at the time of my own graduation, but experience sometimes causes us to change our ideas on many points.

To the man in a hurry to place himself on a dividend-paying basis, I would say that the taking of such a course is in the nature of waiting a few hours for a train to take one on a journey of a hundred miles, or so, rather than impatiently starting out at once to walk. One is often inclined to feel that in so large a plant, an individual is lost sight of, and finds it difficult to advance This is really not the case at all, however, and it is surprising how soon a capable apprentice is heard of by department heads. Even if one does not expect to remain with the manufacturing company, the training offered by such a course forms a most excellent basis for securing good positions elsewhere.

My own experience with college men has not been extensive enough to permit me to make any comparisons between graduates of the Institute and those of other colleges, which would not be comparisons of individuals, rather than of the training afforded by the various institutions. For several years, however, I did have as an assistant an '05 Institute graduate whom I found exceedingly capable. He was able to grasp new ideas readily, to carry out the work I assigned to him with a minimum of detailed instructions, and to write good letters and intelligent reports. As an instance of my regard for such qualities, I may say that I put up a stiff fight in order to take him with me when I was transfered to a new line of work about a year after he came to me, and that I was very sorry to lose him a year or so afterwards, when he was assigned to another section, in order that he might be given a better all-around training.

To this specific instance I may add, that each and every Tech man of whom I have ever heard at our works, has been well thought of by his superiors, and has been a credit to himself and to the Institute